

AMI – Challenges and Benefits

SmartMeter™ Experience at PG&E

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**Asian-Pacific Economic
Cooperation Workshop**
Taipei, Taiwan

August 24, 2011





AMI – Challenges and Benefits

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What is an Advanced Metering Infrastructure ?

Who is Pacific Gas and Electric ?

– California's Energy Leadership

Why? Challenges / Opportunities

How? SmartMeter™ Project & Technology

– Utility / Customer Partnership



What is AMI / SmartMeter™?

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“Super Meter Readers”?

Advanced Communications Networks?

Data Mining? Data Presentation?

More Customer Choices? Better Service?



What is AMI / SmartMeter™?

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An Enabling Technology

*Transforming the Business &
Meeting the Challenges of the Future*



AMI Transforms the Utility Business ⁵

Automatic Meter Reading

- Higher resolution data on end points
 - Interval based billing rates

Data Mining and Presentation

- Getting data out to all *authorized* users
 - Customer on-line web portal
 - Customer Service and Account Reps
 - 3rd parties with customer's authorization
 - Maintenance and Operations
 - Capacity Planning and Engineering
 - Revenue Assurance / Theft Avoidance

Service Connection / Disconnection

Outage Management and Service Restoration

Just the “low hanging fruit” !

Matching “**NEW** to the **OLD**” vs. “**NEW** to the **NEW**”



AMI Transforms the Utility Business

Home Area Networks (HAN)

- Customer communications
- Integrated Demand Response



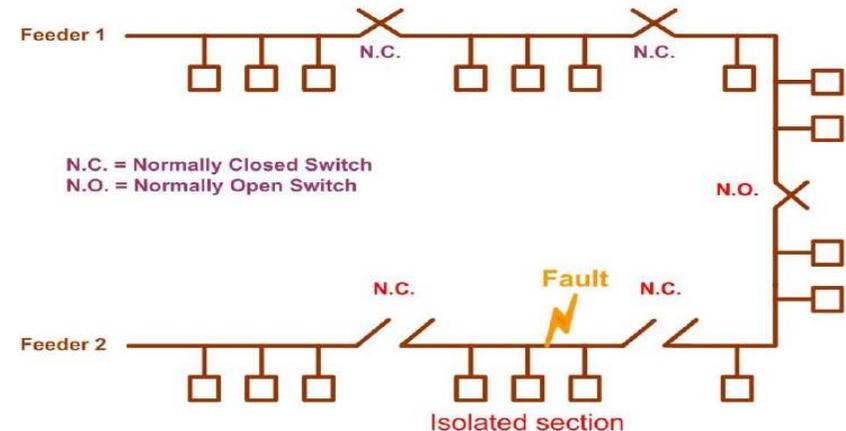
Distributed Intelligence & Processing

- Taking advantage of intelligent end points
- Smart charging of electric vehicles



Basic Distribution SCADA

- Fault Location Isolation and Service Restoration
- Transformer Load Monitoring
- High latency monitoring & control
 - Voltage & Current
 - Out-of-band alarms
 - Volt / VAR control
- Foundational for Smart Grid applications





AMI Transforms Customer Relationships

How Utilities relate to Customers

- Partnership to manage energy resources more efficiently and intelligently
- Provide more energy management options



How Customers relate to Energy

- Visibility into the real cost of energy
- Effective management and control of their energy
 - Energy is *not* an endless resource or a simple commodity





Pacific Gas and Electric Company

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Energy services to 15 Million people:

- 5.1 M Electric customer accounts
- 4.3 M Natural Gas accounts

70,000 sq miles (181,000 KM²) with diverse topography

18,610 miles (29,950 KM) interconnected transmission lines

123,054 miles (198,036 KM) electric distribution lines

Peak load: 22,554 MW on July 25,2006

20,000 employees

A regulated, investor-owned utility



Ranked the greenest utility in the United States



PG&E's Commitment to Customers⁹

Deliver safe, reliable energy

Provide clean, renewable energy options

Provide tools and information on how to become smarter energy consumers

SmartMeter™ is a key enabler



California's Forward Thinking Energy Policies

Long-standing State policies lower carbon footprint

30+ years of energy efficiency programs facilitated by “decoupling” of rates

California Energy Action Plan's preferred loading order



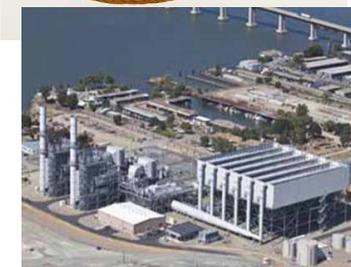


California's Energy Action Plan

- Preferred Loading Order

11

1. Energy Efficiency / Demand Response
2. Renewable and Distributed Energy
3. Clean, gas-fired Generation

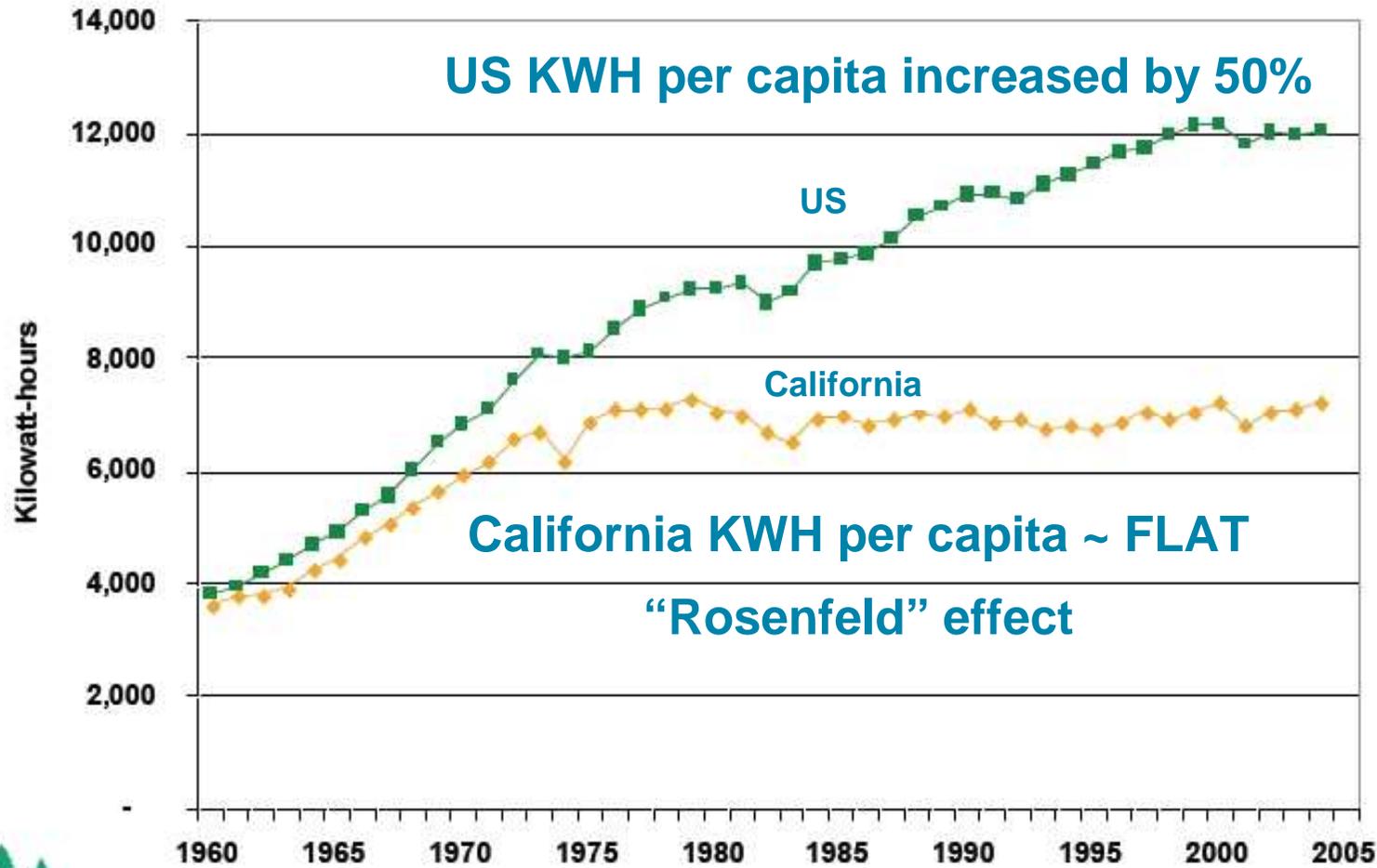


“The most important aspect of the Energy Action Plan was the concept of a ‘loading order’ for energy resource procurement. In that loading order, we defined energy efficiency as our first priority. Implicit in that priority was also demand response or price-responsive demand.”

- CPUC Commissioner Peevey



Per Capita KWH Comparison



Source: California Energy Commission, 2004



Why? Challenges/Opportunities

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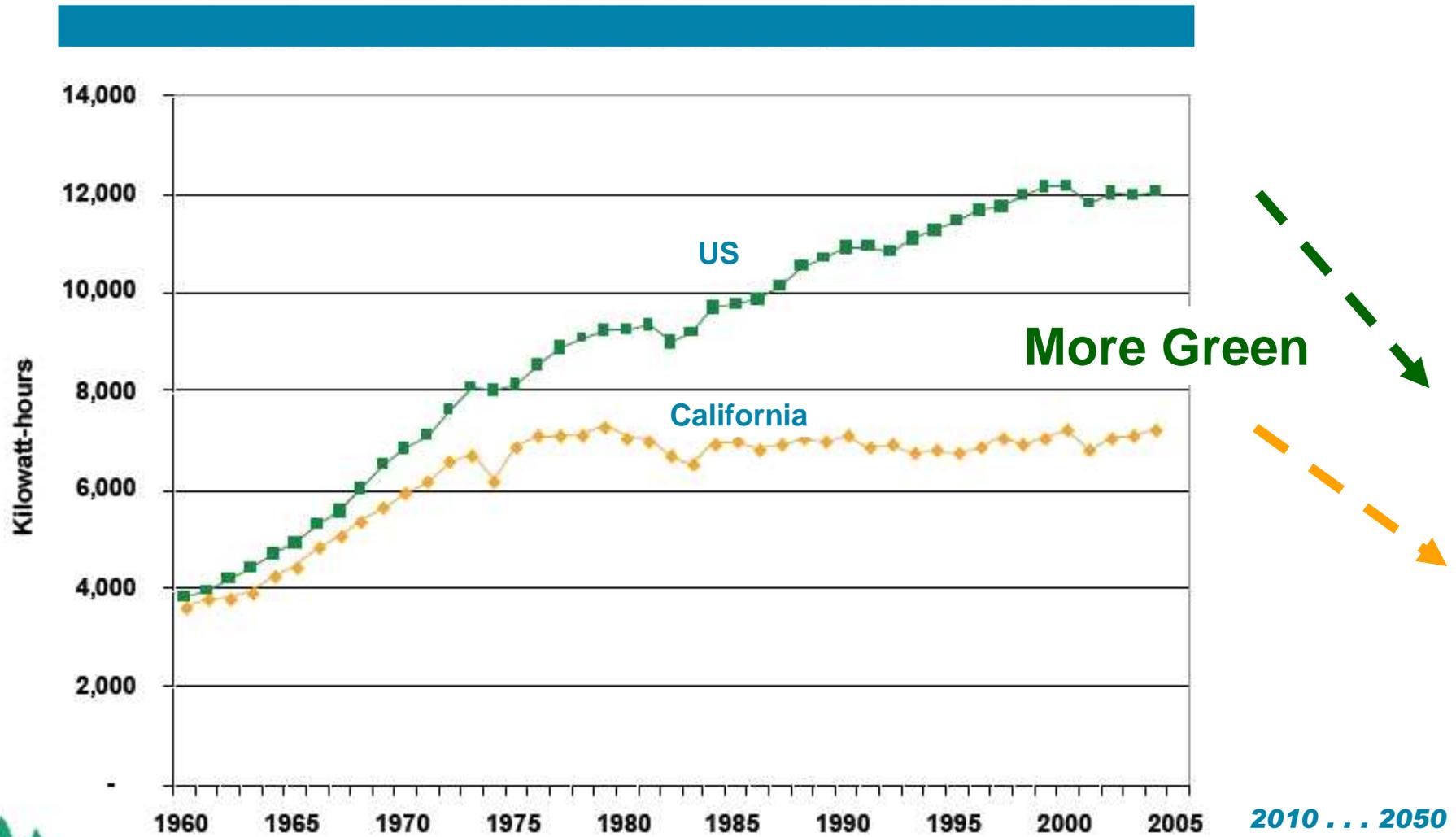
Rising energy requirements, while still reducing per capita energy use

- Becoming even more **“Green”**
 - Being more energy efficient





Per Capita KWH Future



Source: California Energy Commission, 2004



Why? Challenges/Opportunities

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Rising energy requirements, while still reducing per capita energy use

- Becoming even more “Green”

Fewer new fossil fuel power generation plants

More distributed generation and intermittent power resources from renewables

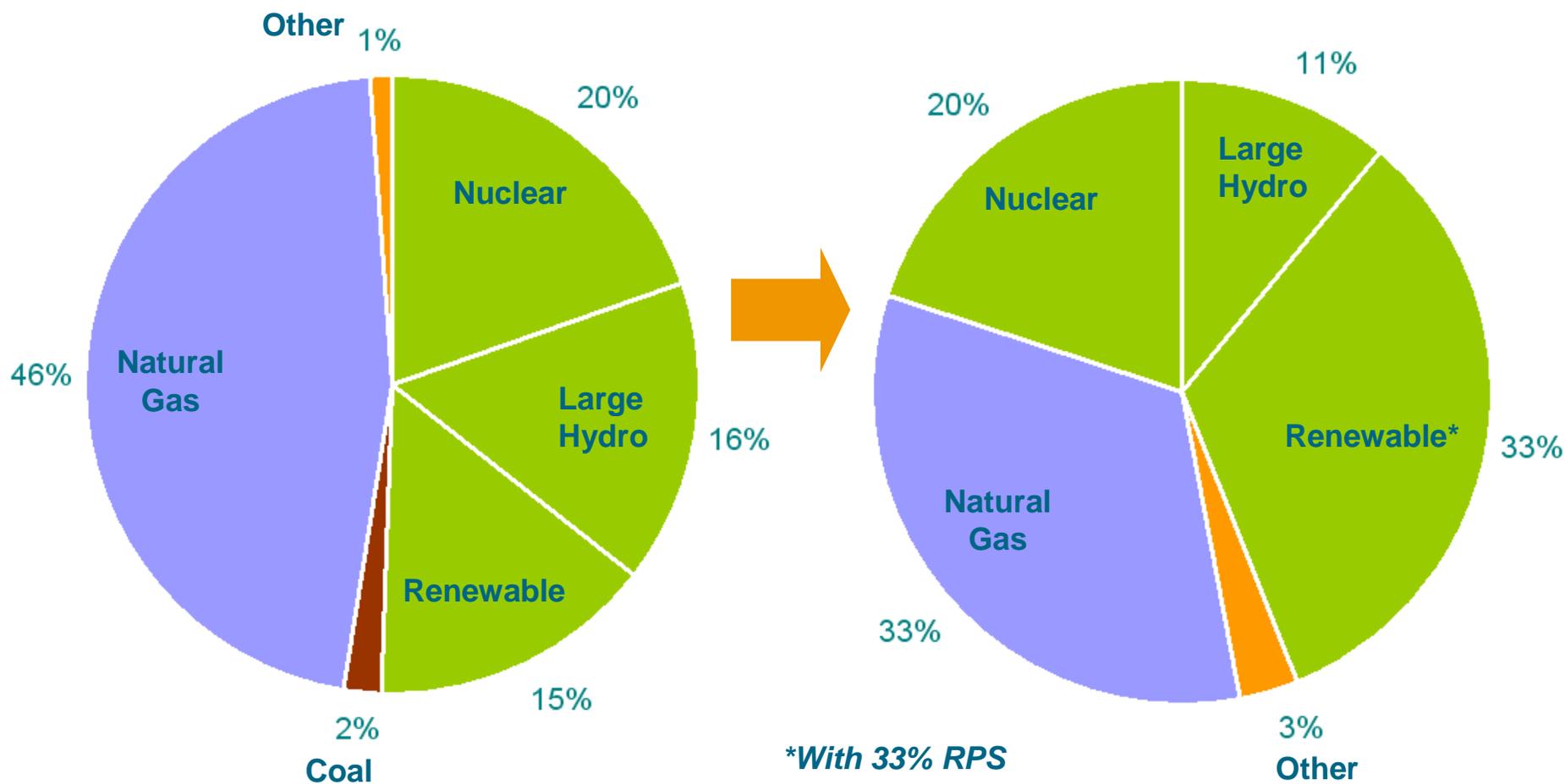




PG&E Projected Power Mix

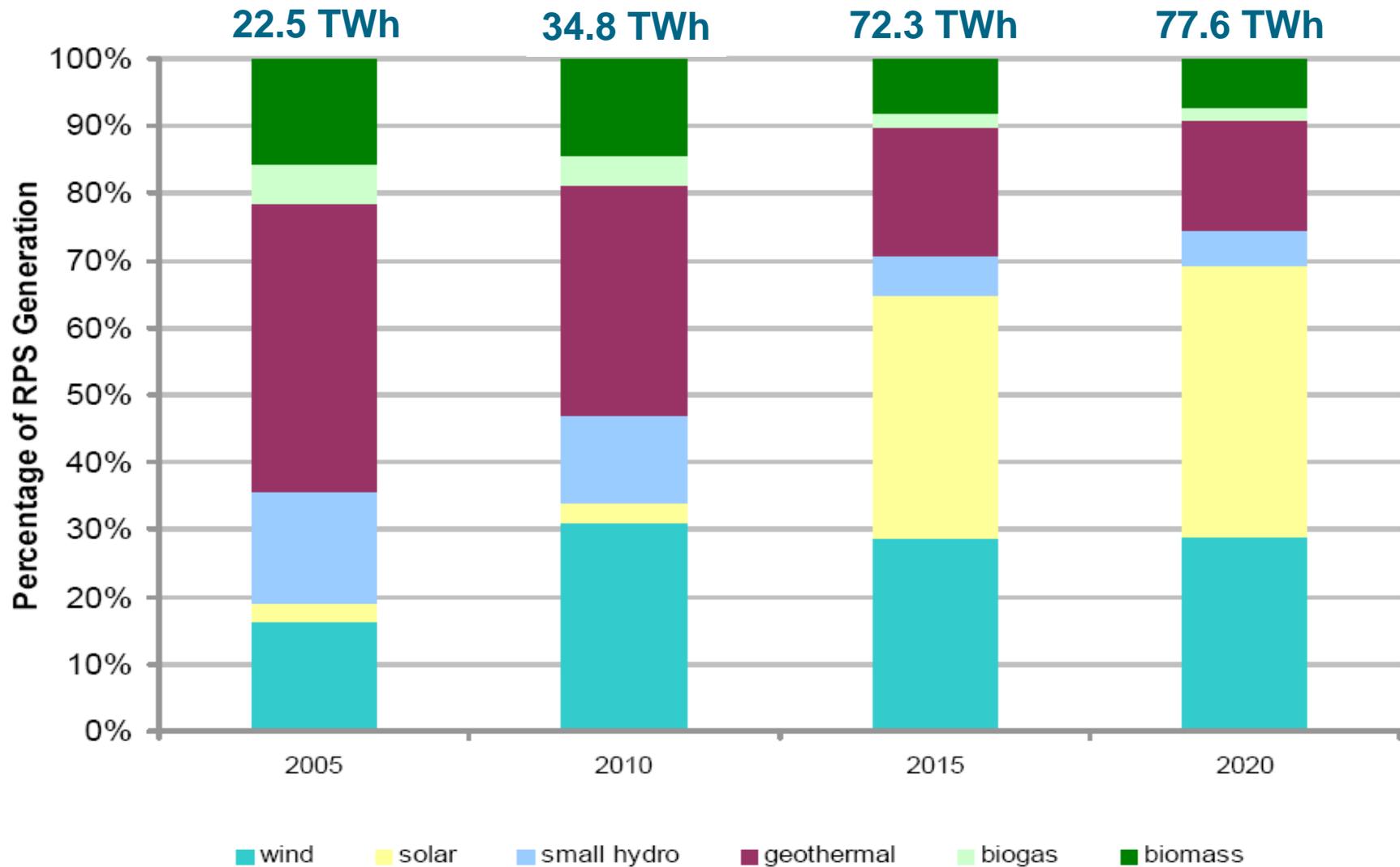
2010

2020





California's Changing Renewable's Mix



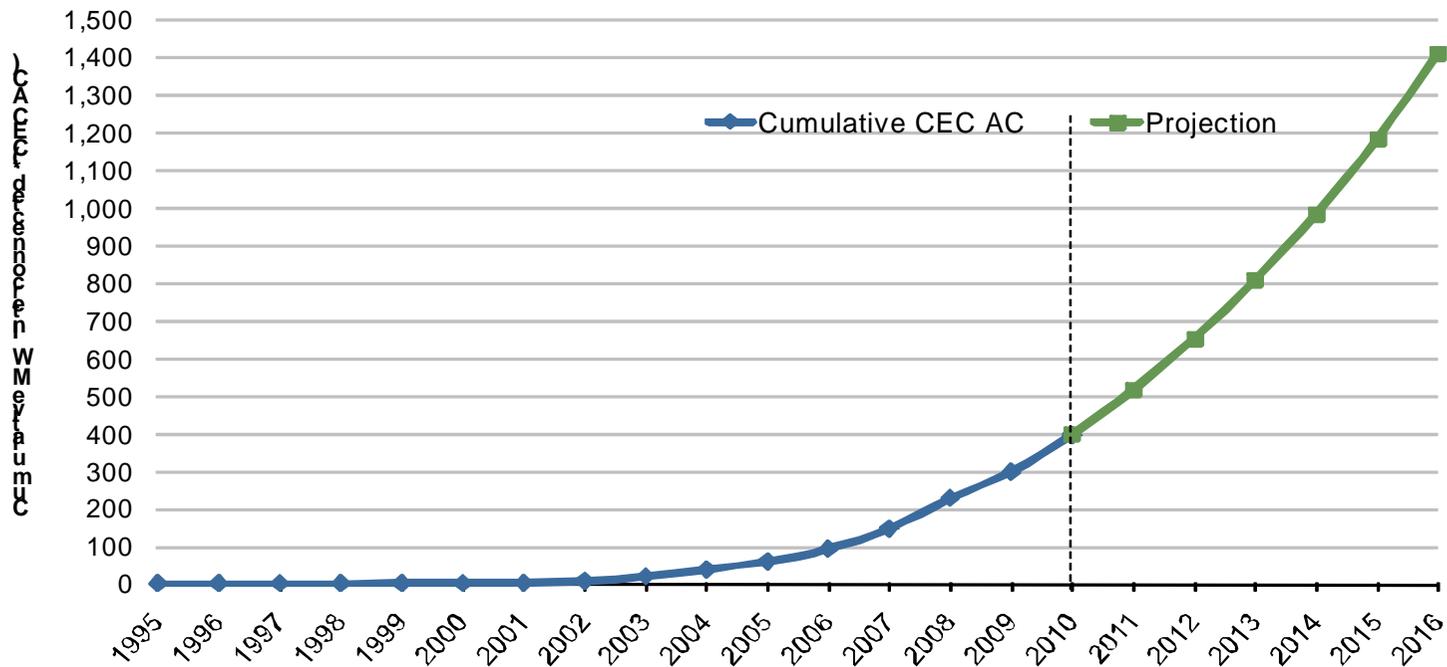
Source: California Public Utilities Commission, July 2009



Distributed Customer Generation

More than 45,000 PG&E customers have onsite solar generation

Cumulative Capacity of NEM (MW, CEC AC)
Interconnected with PG&E Grid*



* Includes all PV and Wind NEM (and VNEM) projects, excludes Non-Export projects

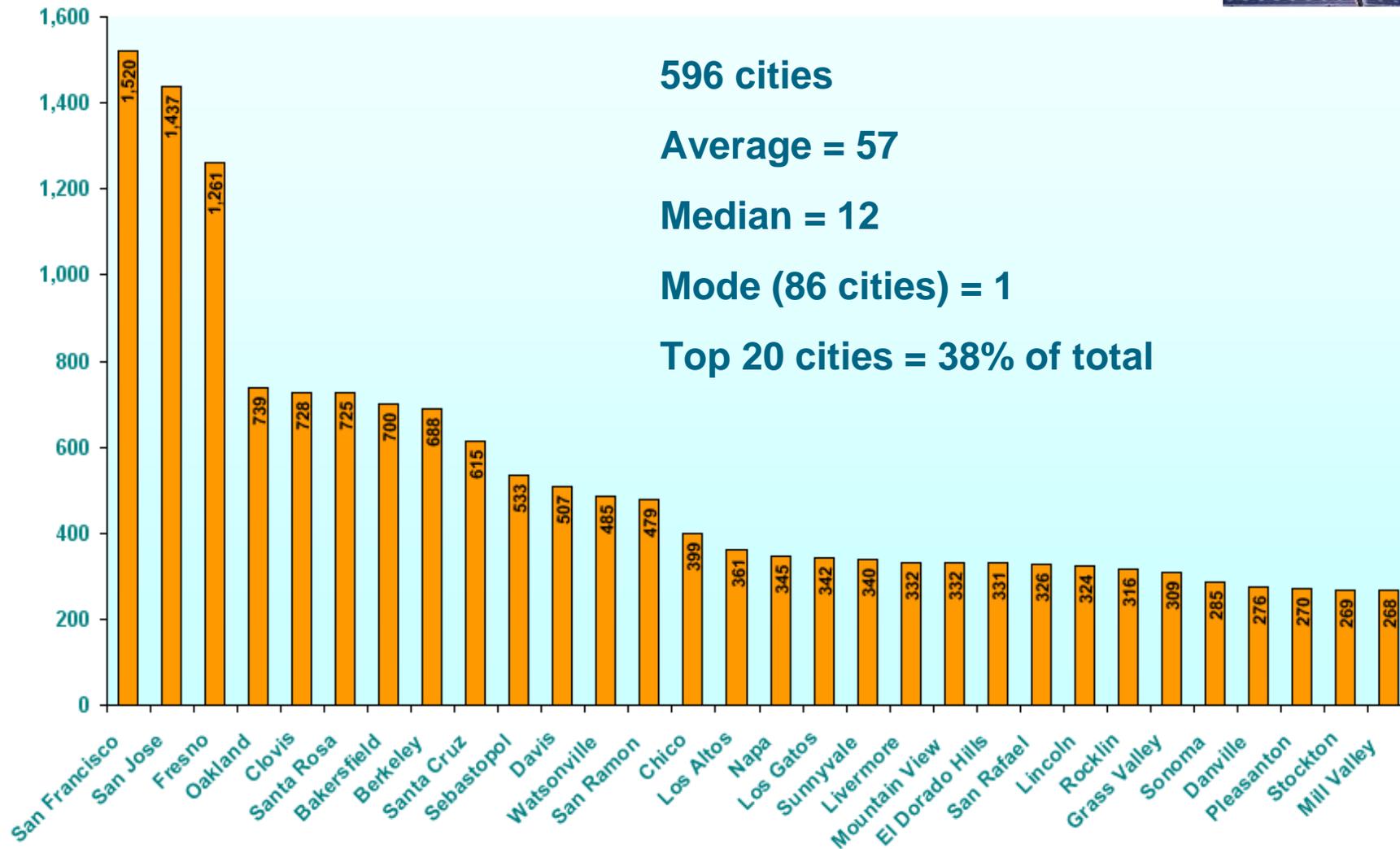
~35% of US residential PV interconnections are in PG&E's service territory



PV Solar Is Concentrated



PV Interconnections by City



596 cities

Average = 57

Median = 12

Mode (86 cities) = 1

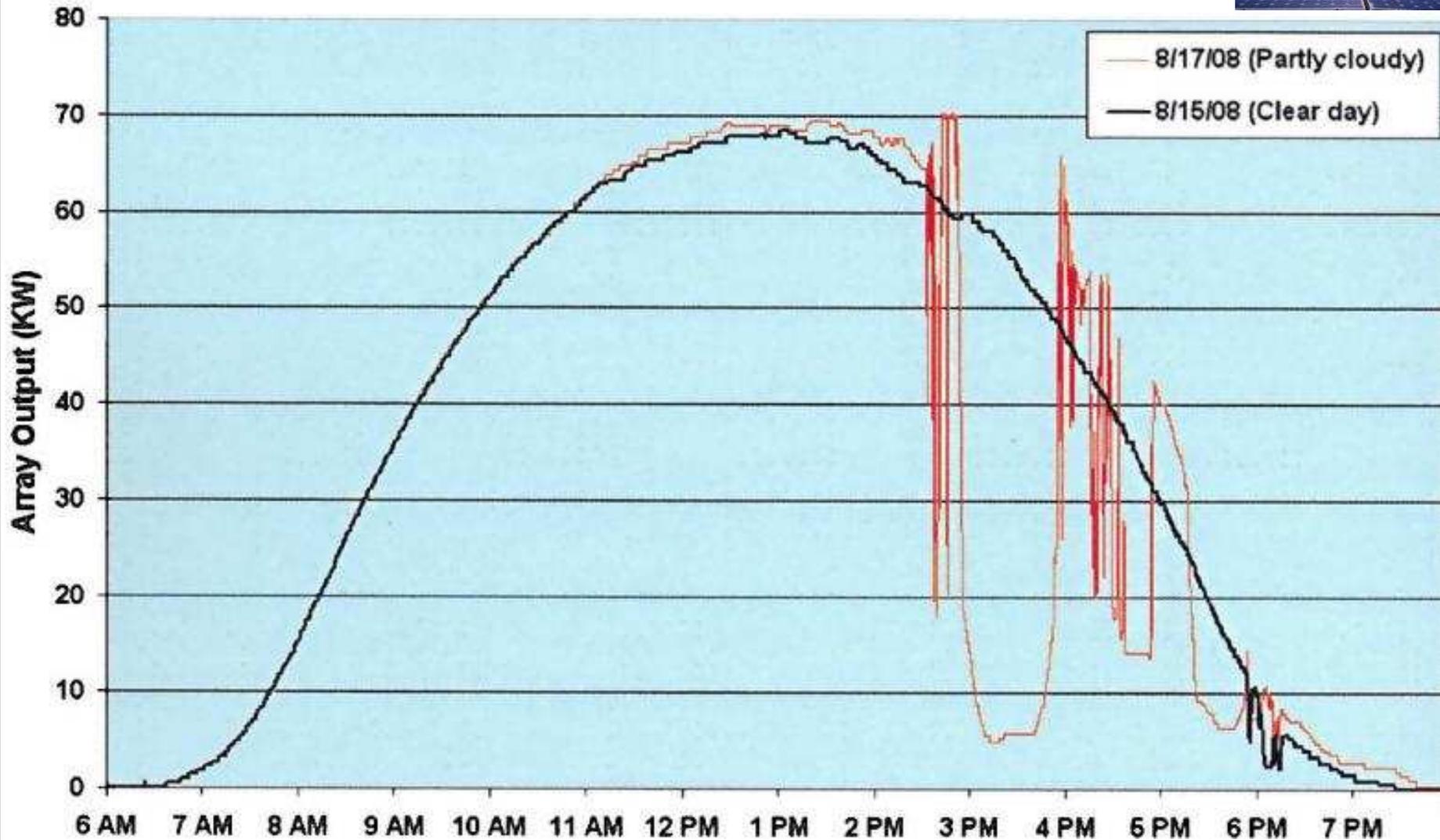
Top 20 cities = 38% of total



PV Solar Output - Intermittent



Nevada 70 KW polycrystalline array (ten second data)

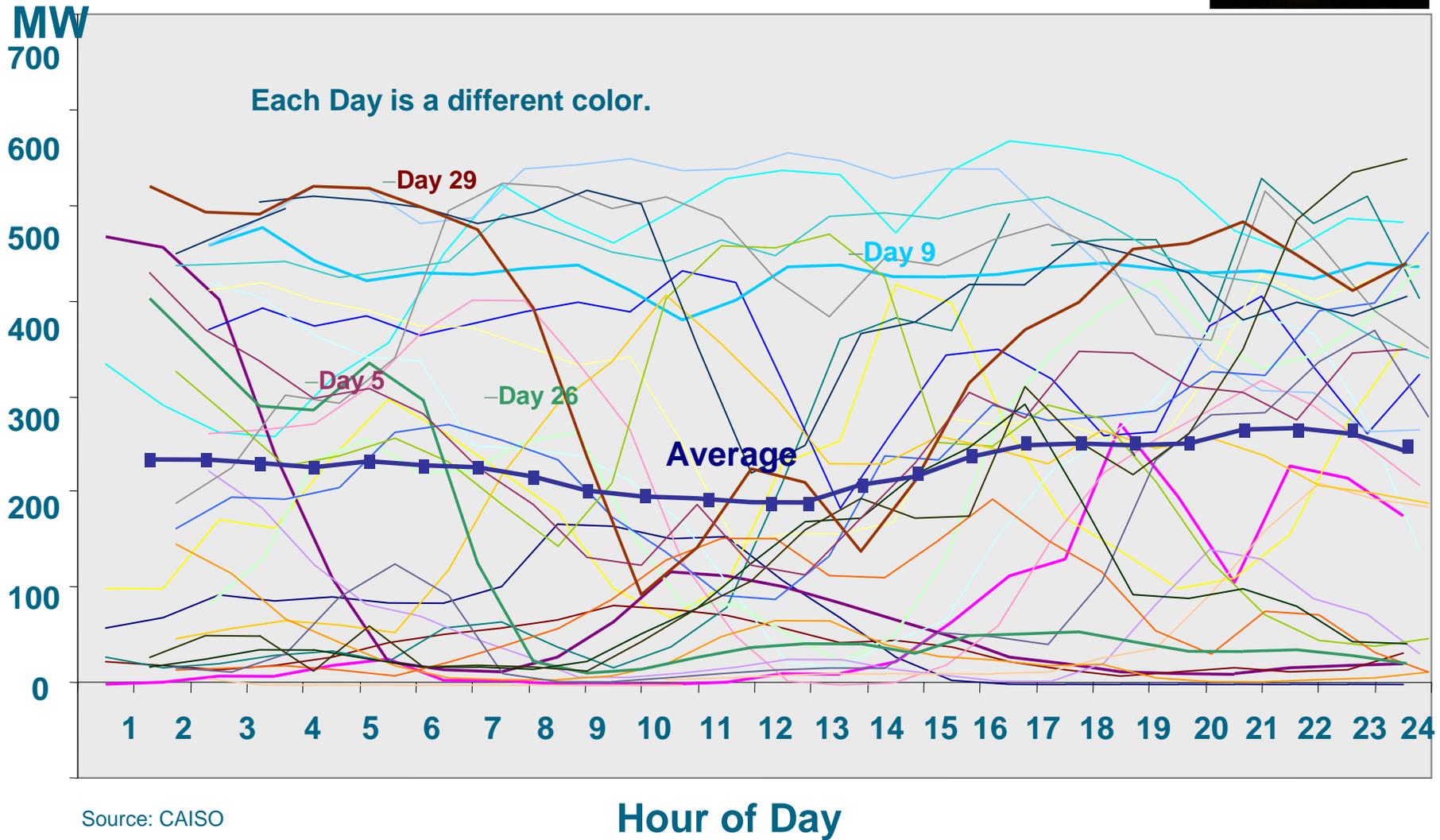




Wind Farm Output



Smooth average, but great day-to-day variability





Why? Challenges/Opportunities

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Rising energy requirements, while still reducing per capital energy use

- Becoming even more “Green”

Fewer new fossil fuel power generation plants

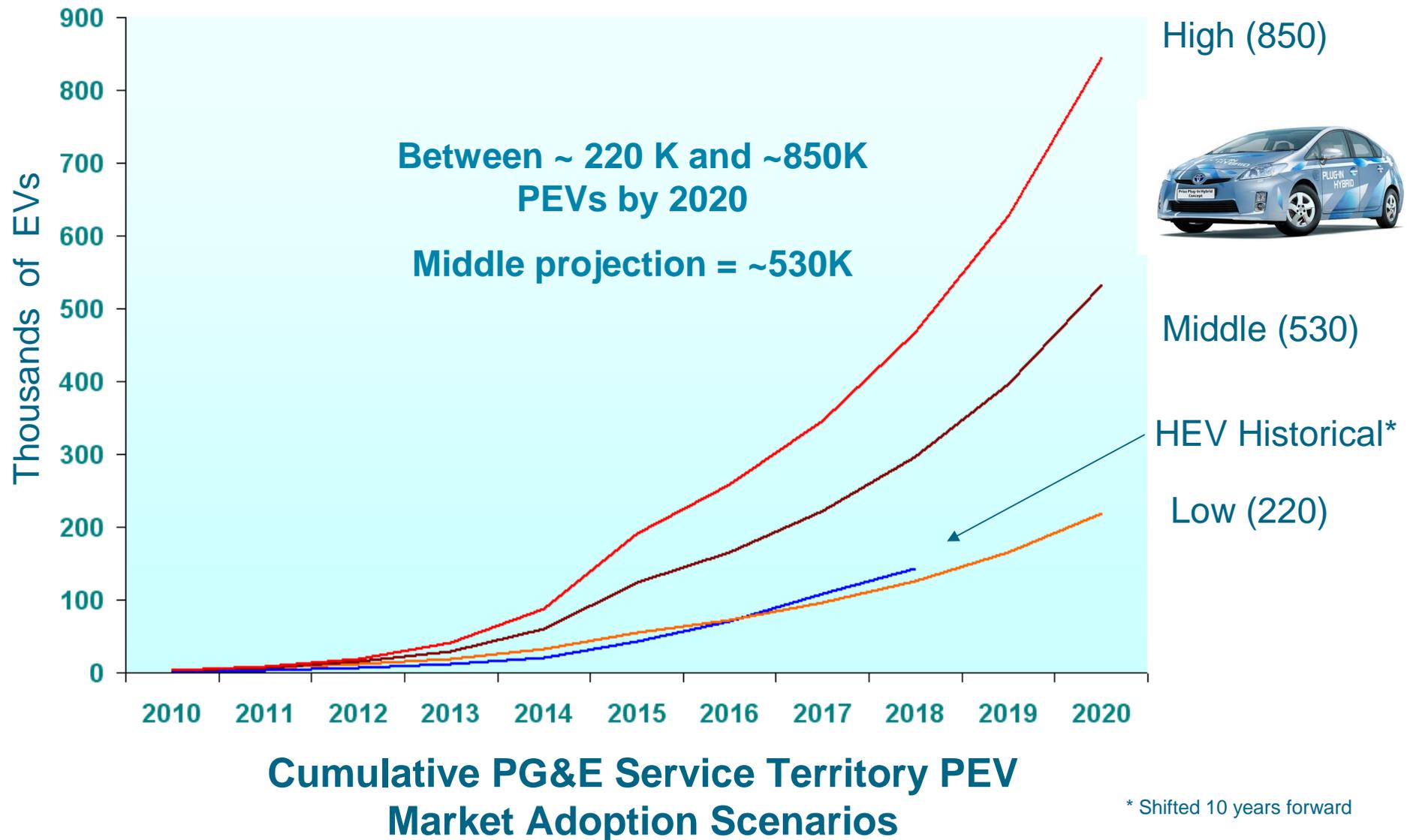
More distributed generation and intermittent power resources from renewables

More large concentrated loads





Projected Electric Vehicle Growth



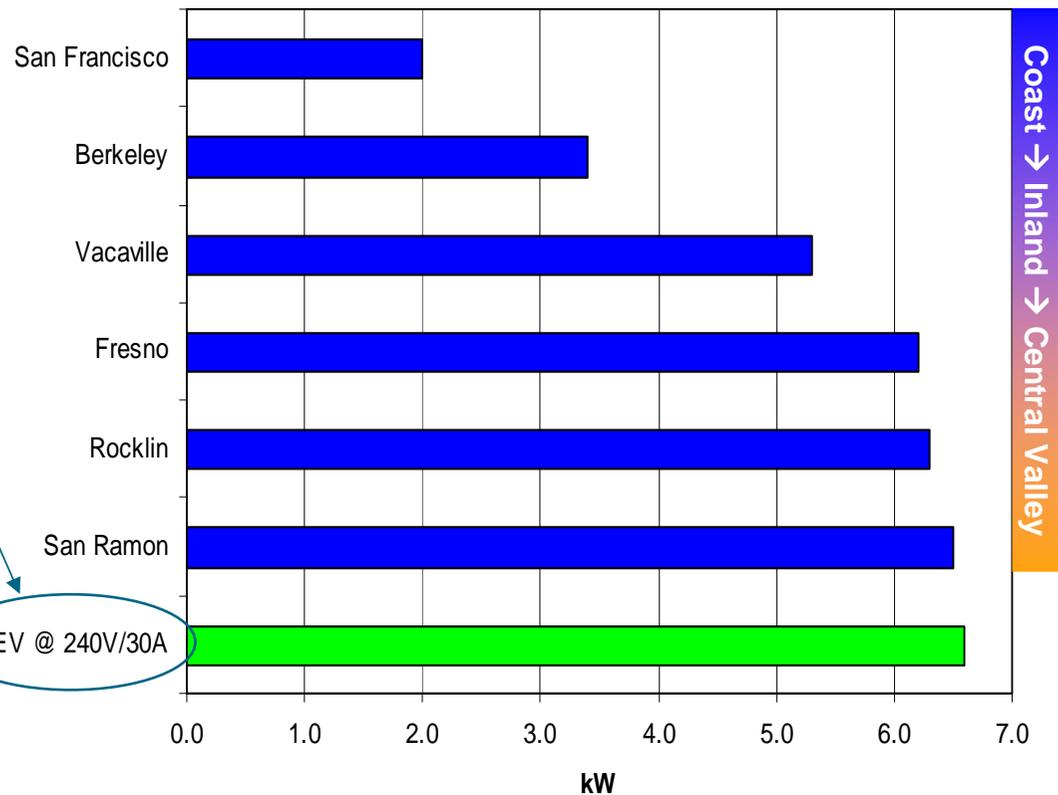
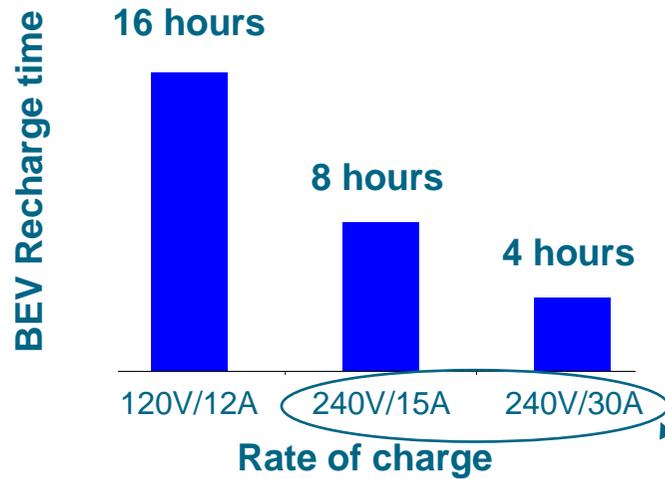


EV Charging Creates A Significant Increase In Load

Customers will prefer a 240V charge to shorten recharge times



EV charging is a large load for PG&E customers, comparable to average peak summer load of 1 – 3 homes

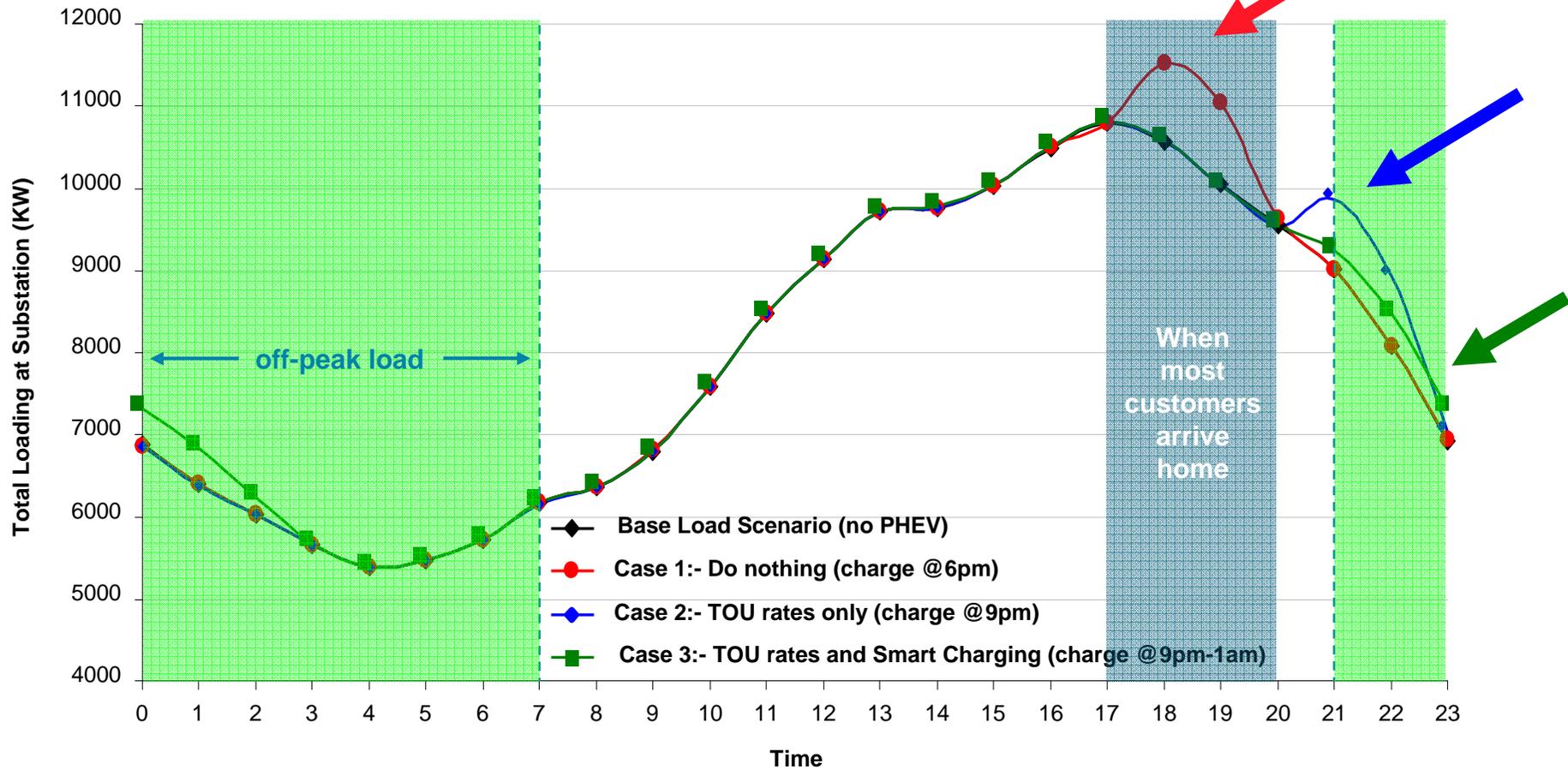


Source: <http://www.nissanusa.com/leaf-electric-car/#/charging>, August 14, 2009



Unmanaged EV loads will add to peak electric demand

24 Hour Total Loading of Single Feeder - July 27, 2007



Source: EPRI.

Note: Feeder of Northeastern utility feeder during urban summer peak with 2,778 residential customers. PEV penetration = 10%. Case 1 – 3 charge @ 240V, 12A

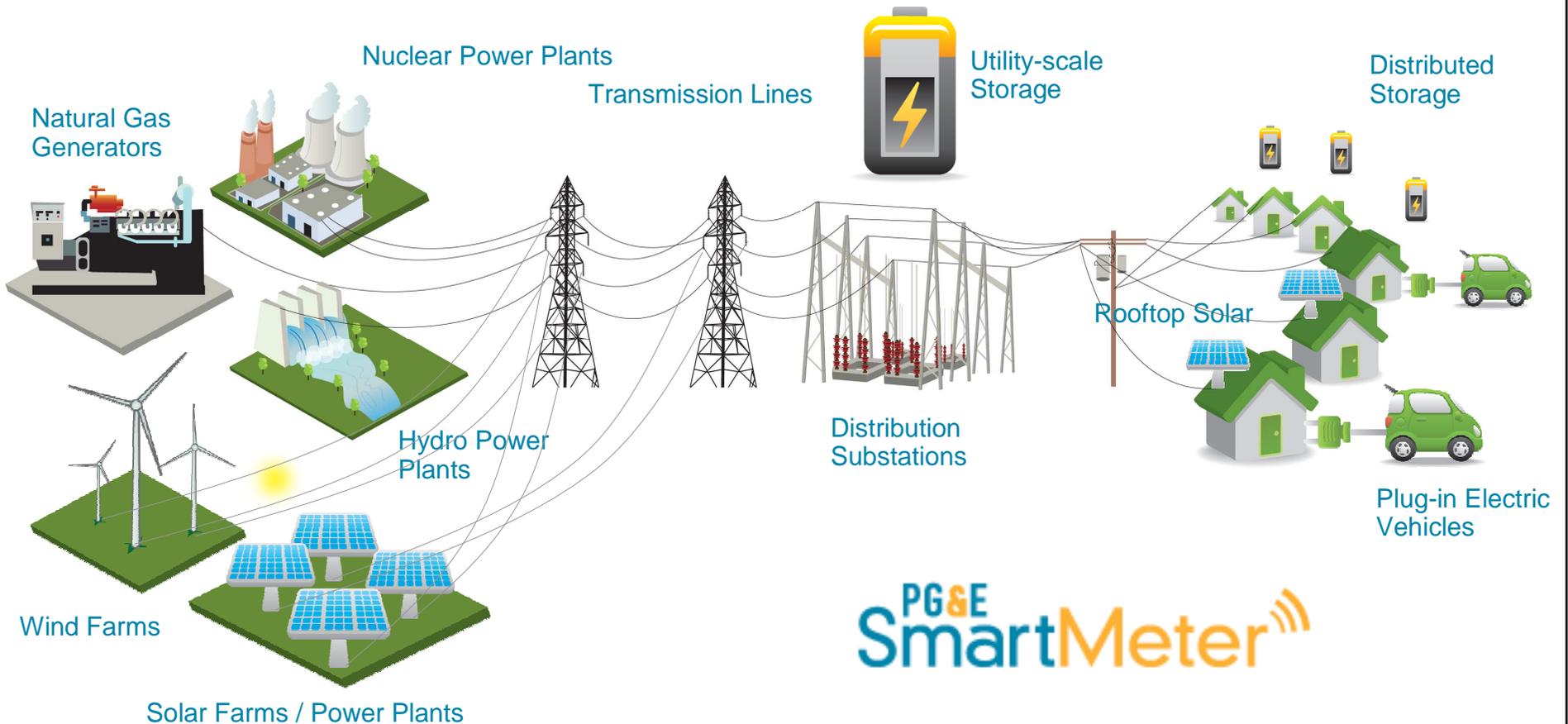


How? A Sustainable Electric System

Power Plants

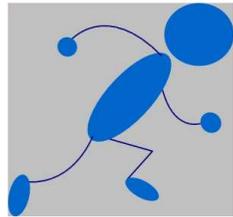
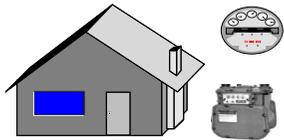
Electric Grid

Customers

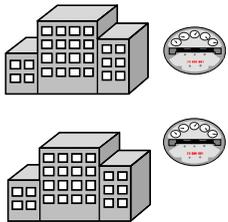




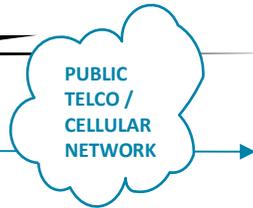
Before SmartMeters™



Manual Metering Reading



AMR
Large Commercial/Industrial



MV90



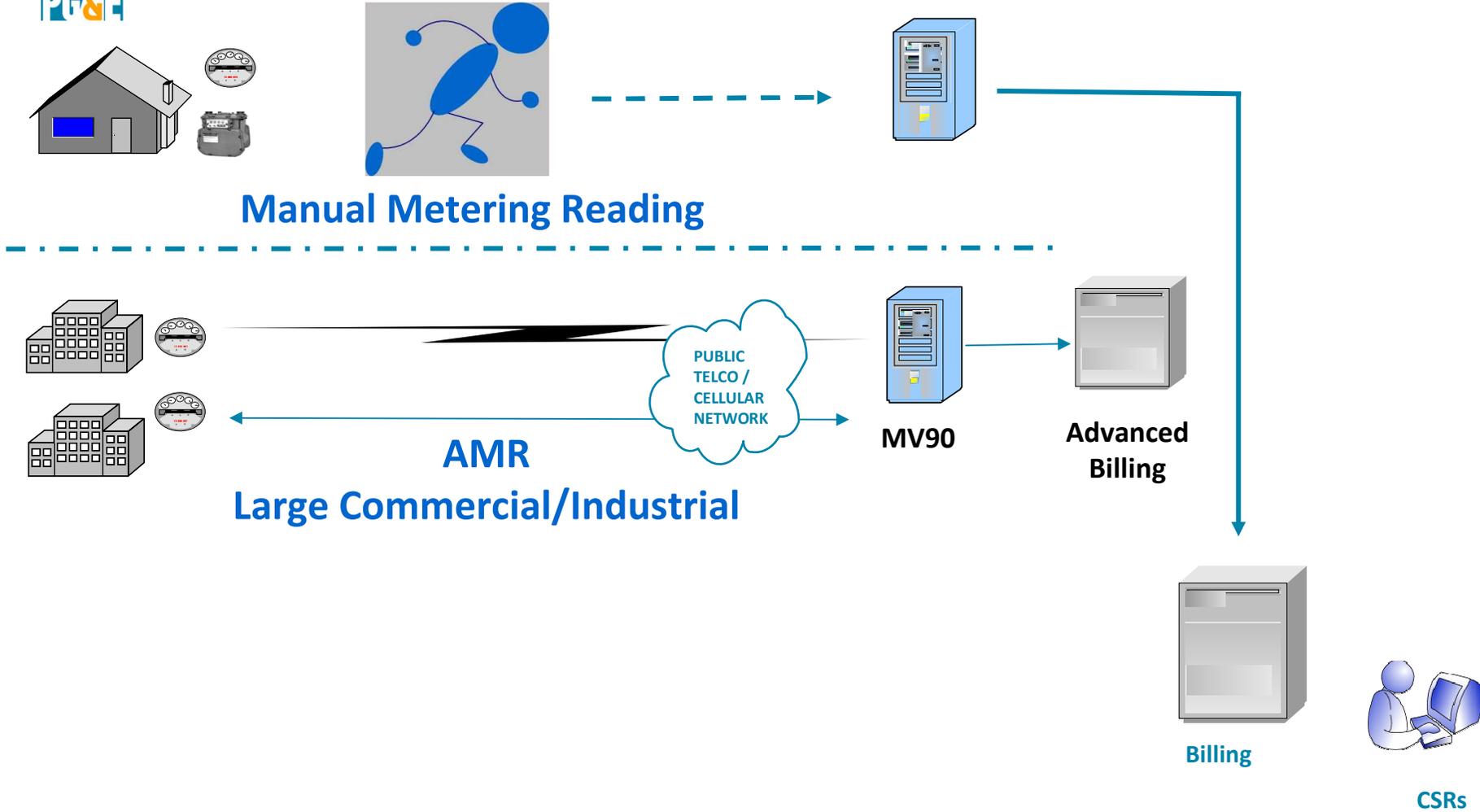
Advanced Billing



Billing

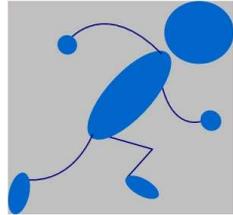
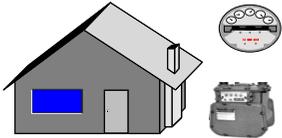


CSRs

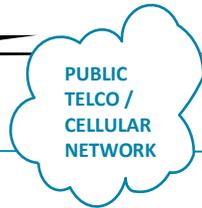
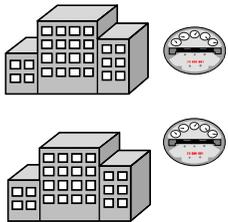




After SmartMeters™



Manual Metering Reading



AMR

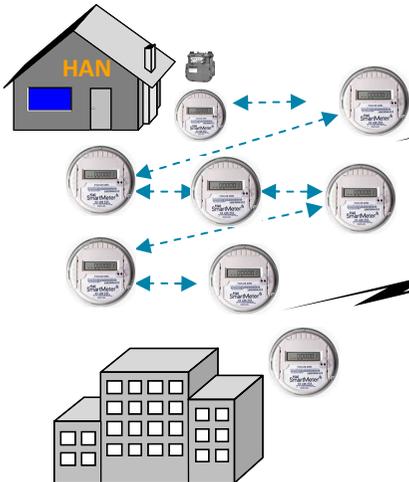
Large Commercial/Industrial



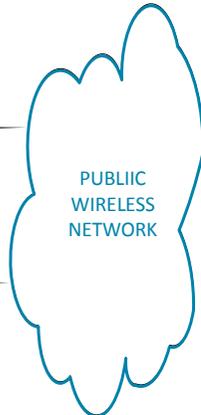
MV90



Advanced Billing



Access Points



PUBLIC WIRELESS NETWORK



AMI System Head Ends



MDMS



Billing



Data Warehouse



CSRs and Other End Users





PG&E's SmartMeter™ Program

– Largest AMI Deployment in North America



AMR for all customers

- 8.3M SMs already installed

15 min, 60 min, & Daily meter reads

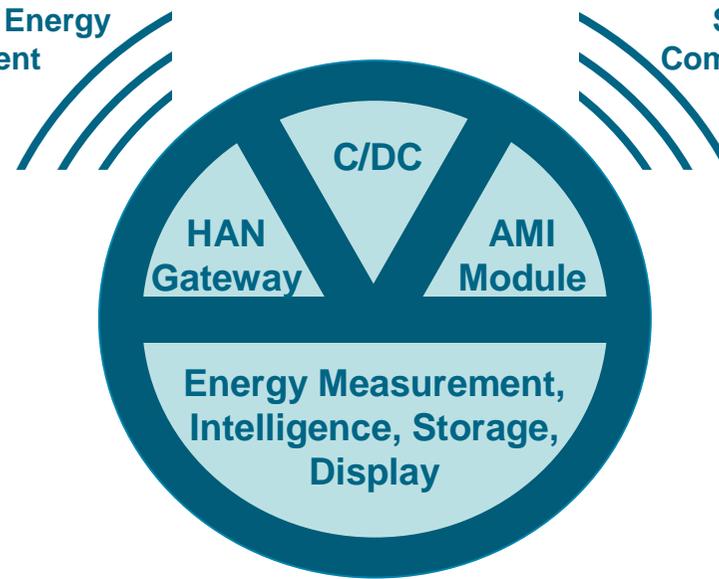
- Scheduled and Ad Hoc

Platform for future innovations



Customer Energy Management Network

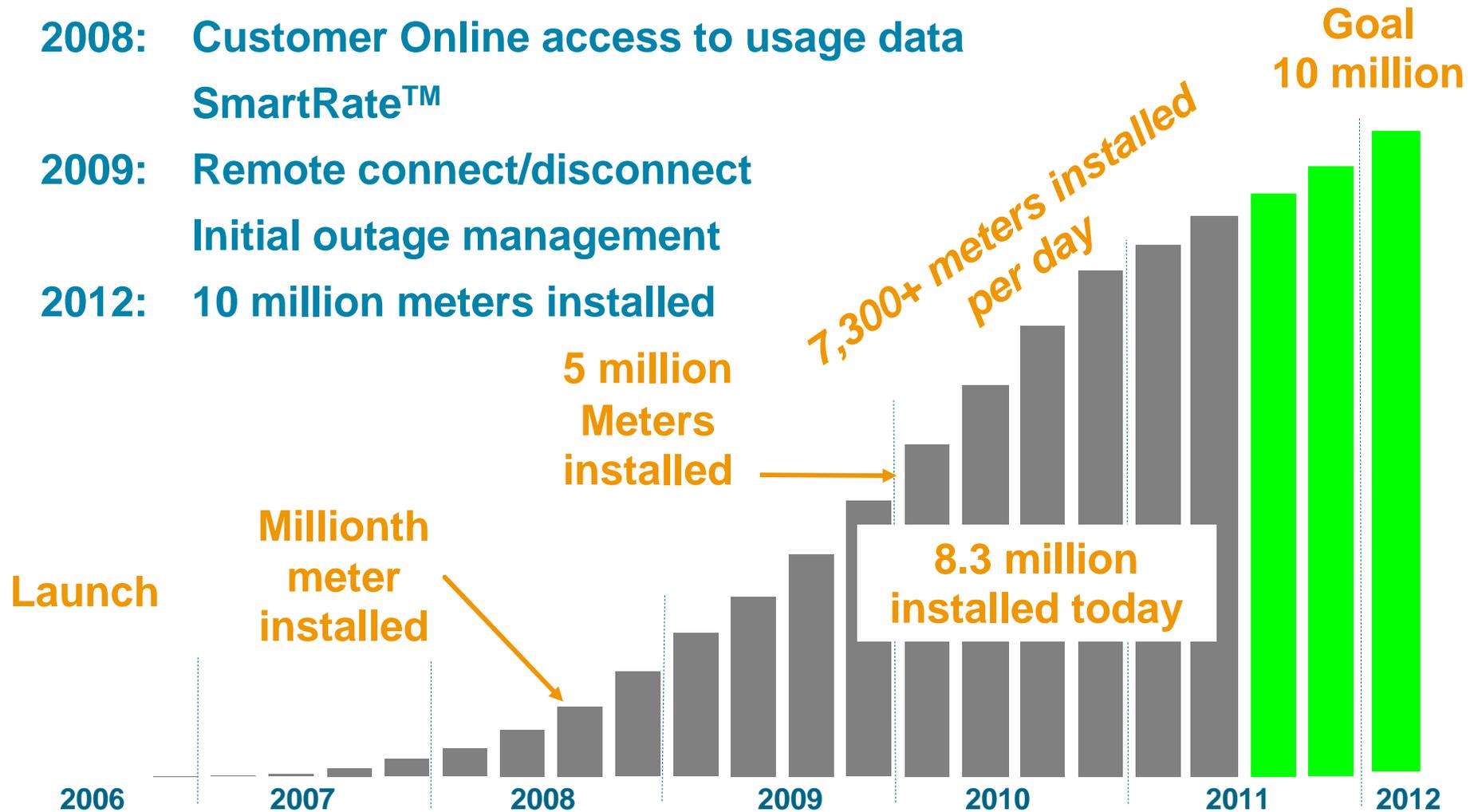
SmartMeter™ Communications Network





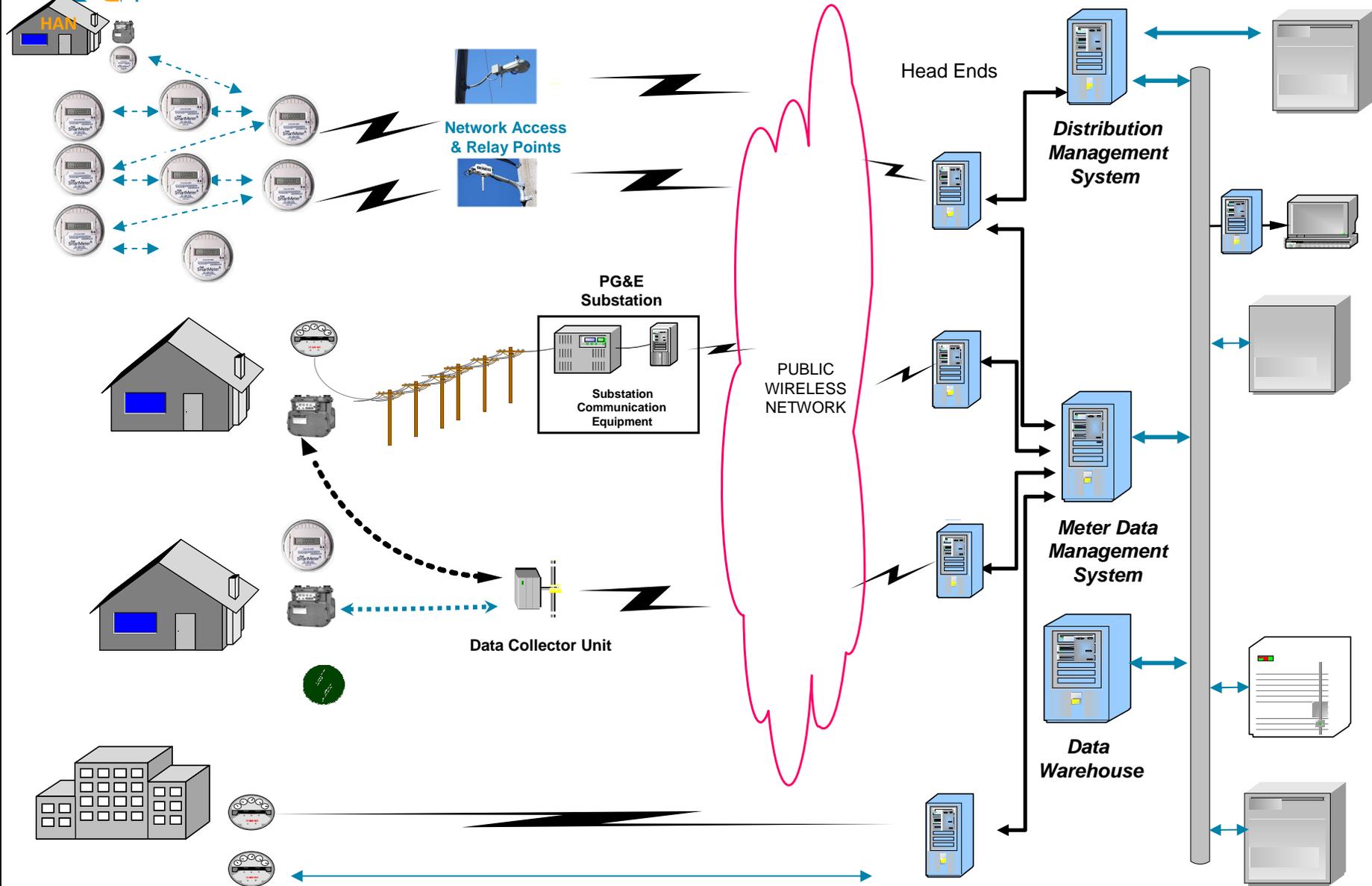
SmartMeter™ Timeline

- 2005:** 5,000 Meter Pilot
- 2006:** Full Deployment Launch
- 2008:** Customer Online access to usage data
SmartRate™
- 2009:** Remote connect/disconnect
Initial outage management
- 2012:** 10 million meters installed



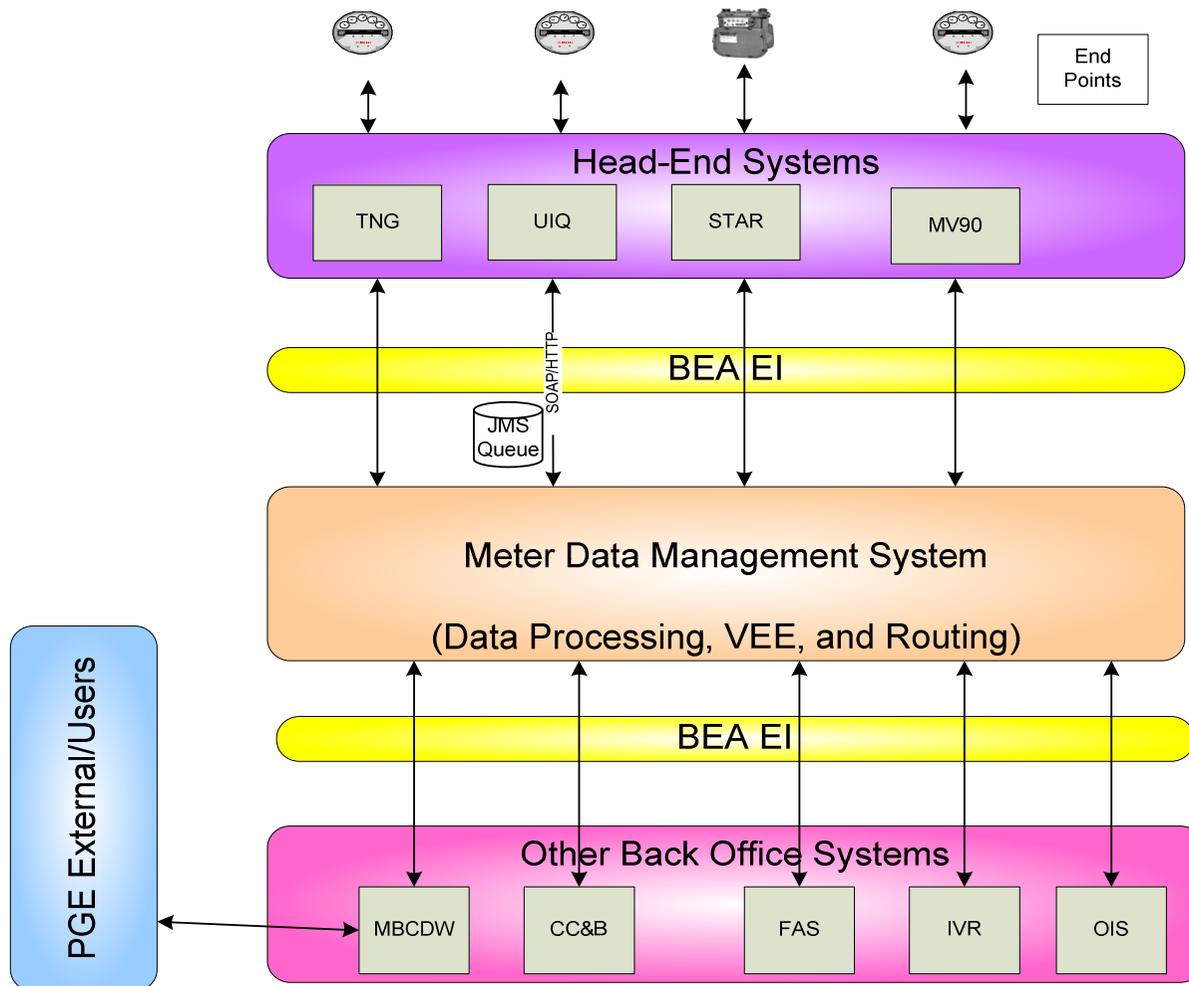


SmartMeter™ Architecture





SmartMeter™ Architecture





SmartMeterSM Architecture - notes

Multiple AMR systems / networks (4)

Meter Data Management System (MDMS)

Many back office systems (35+ systems)

- Procurement, Delivery, & Asset management
- Deployment
- Billing – Meter to Cash
- Customer / Energy use data warehouse – data presentation
- Customer web portal
- Outage information system
- Demand Response

System integration (150+ interfaces)

- Service Oriented Architecture (SOA)
 - Open Standards
 - Enterprise Service Bus
 - Web services
 - Common Information Model (CIM)

Security & Privacy



Meter Data Management System - notes

Why use a MDMS?

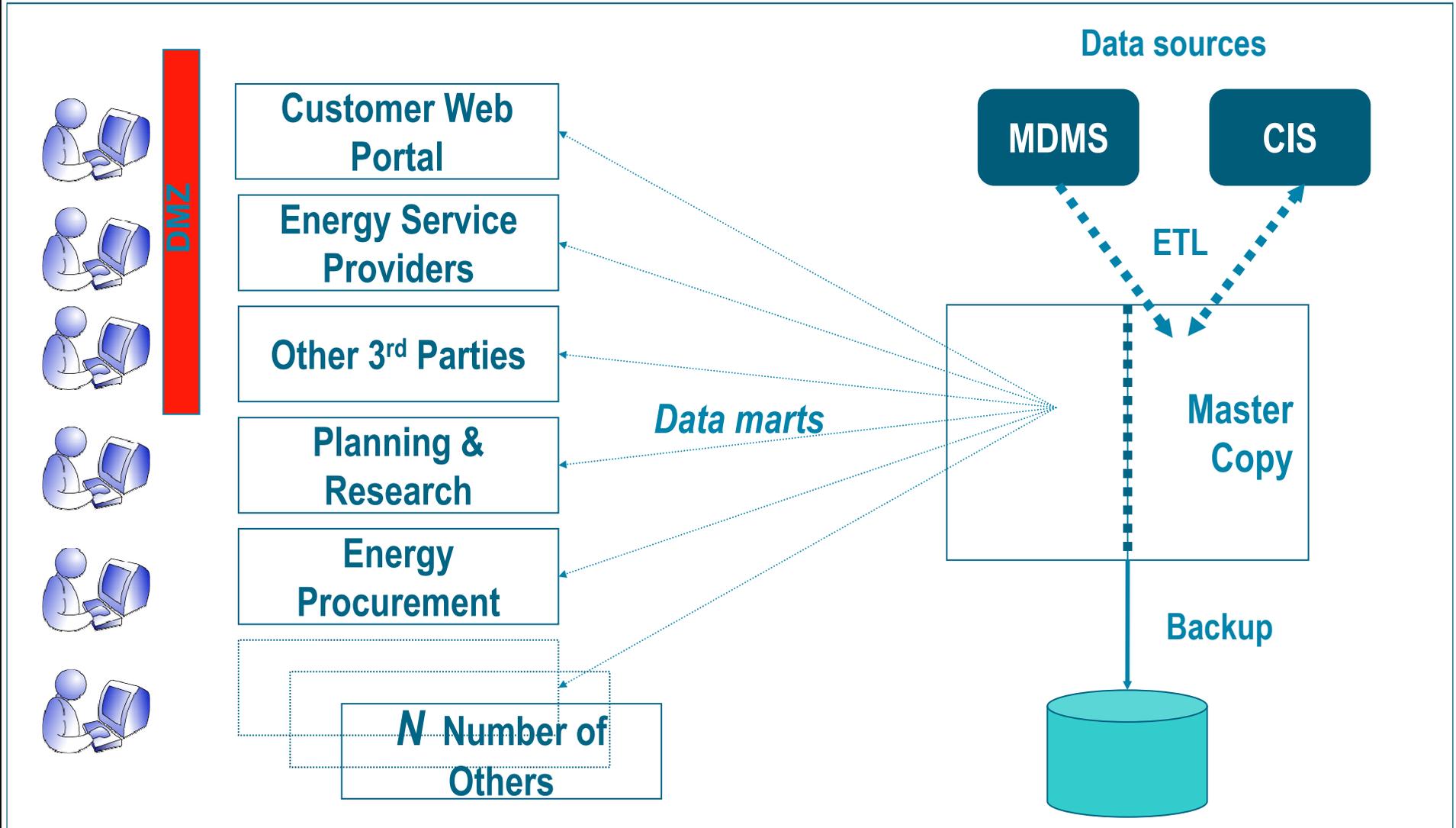
- Loose coupling of systems
- Multiple inputs and multiple outputs
- End user transparency
- Traffic Director / Conductor
- “Plug and Play” flexibility
- Upgrades and replacements

MDMS Functionality

- Validation, editing, and estimation (VEE)
- Framing billing determinants
- Connectivity model
 - Meter-Transformer-Circuit-Substation
- Asset management support
- Data warehousing / mining



Customer / Energy Use Data Warehouse ³⁶



Data replication to partitions for quick response & low impact on operational systems.



SmartMeter™ Program Benefits

Customer Service

Provide our customers more convenience and better, faster service

- Convenient meter reading
- Faster power restoration
- Remote connect / disconnect
- Faster problem resolution
- Better billing

Choice and Control

Provide our customers greater choice and more control over their energy bills

- Energy usage data
- New time-of-day pricing options

Enable the Future

Put in place a platform for innovation

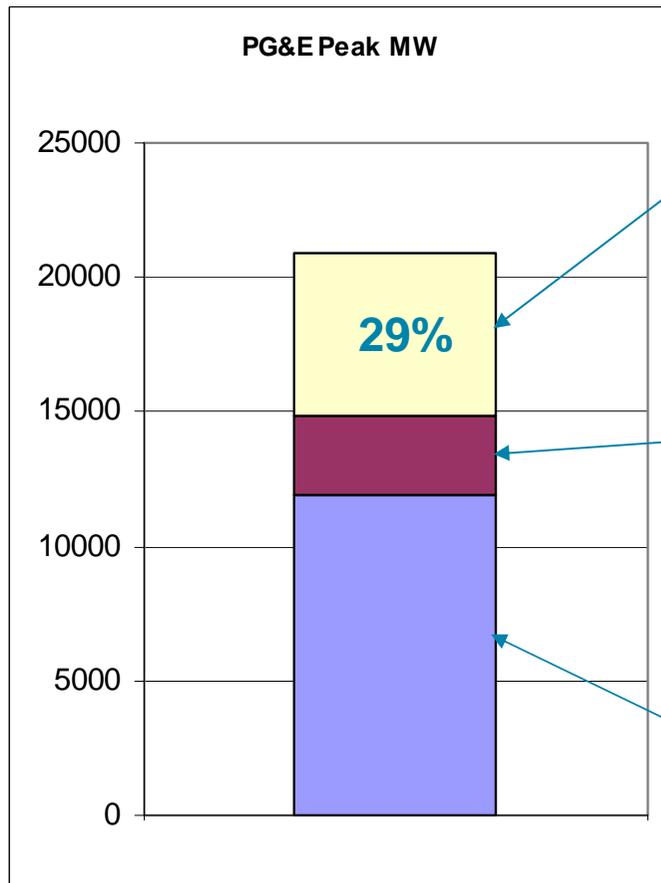
- Automated customer energy management
- Distributed generation and storage
- Electric vehicles



Enhance the value our customers receive from their energy expenditures



Untapped Demand Response Opportunities *before* SmartMeters



Large Commercial and Industrial (>200 kW)

- Air Conditioning
- Lighting
- Refrigeration
- Process

Med Commercial / Industrial (20 kW-200kW)

- Air Conditioning
- Lighting
- Refrigeration
- Process

Residential and Small Commercial (<20 kW)

- Air Conditioning
- Swimming pools
- Plug-in EV (future)

71% of load: limited or no demand response options *before* SmartMeter™



A New Partnership With Customers

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Customer Action

Invest in equipment to lower and/or shift energy use (i.e. energy efficiency)

Conserve: use less energy at all times

Shift energy use from peak times to off-peak times



PG&E Support

Automation equipment: **Technical infrastructure to enable automation of energy use**

Innovative programs and service offerings

- Energy efficiency
- Time-of-day electric prices
- Demand response
- Individualized energy use information

Energy use education and training



Savings



A New Paradigm For Customers

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Electricity =
a ubiquitous commodity



Electricity =
a precious resource

Flat, tiered electric pricing

Limited or no visibility to specific cost of electricity use

Low energy awareness

Limited energy management options

**Utility = Service Provider
Customer = Limited Awareness**

Dynamic, time-differentiated pricing

Full visibility to cost of electricity use

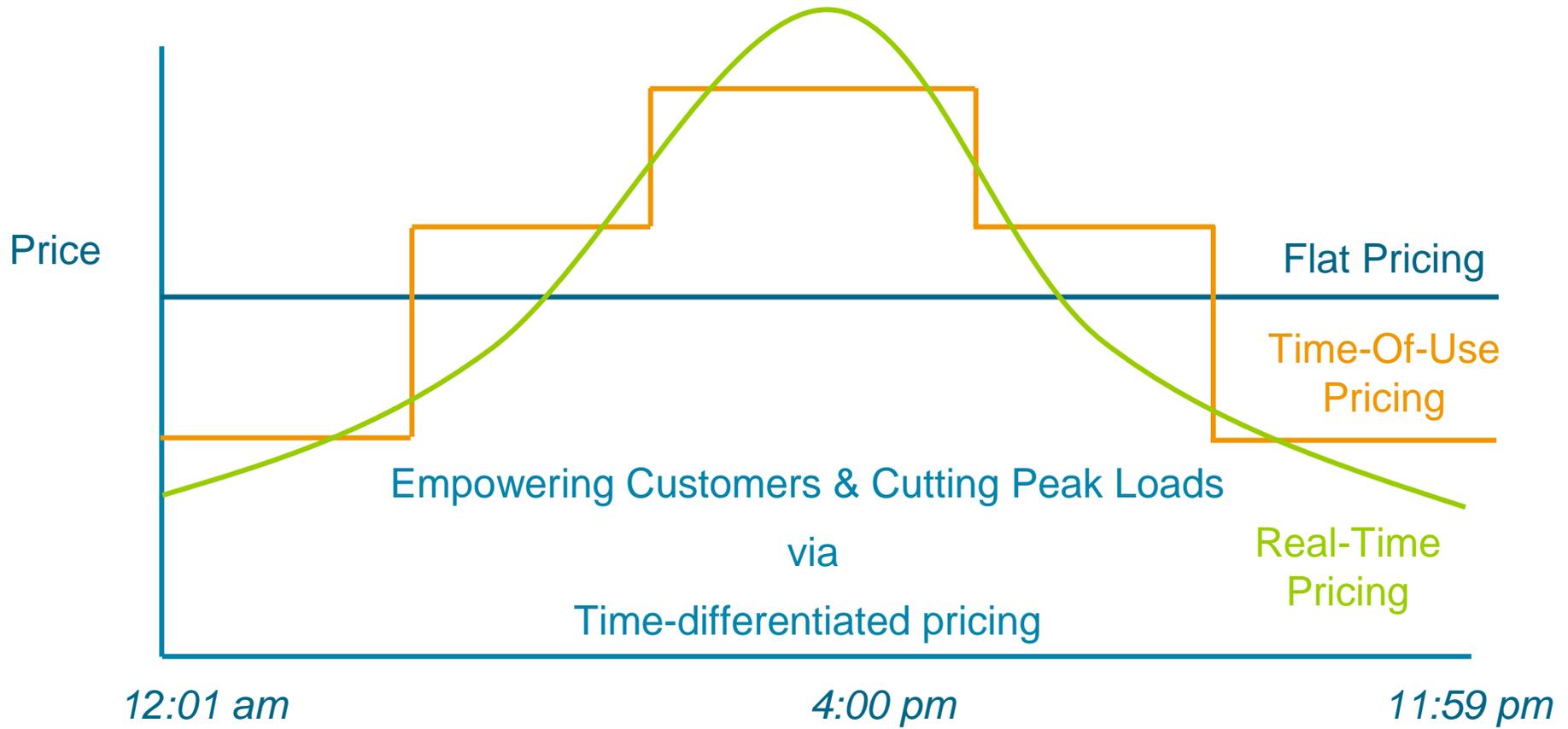
High energy awareness

Robust energy management options

**Utility = Energy Partner
Customer = Active Participant**



New Rate Plans



Encourage smarter energy use by exposing customers to the real marginal cost of electricity



Customers Can View Their Energy Use

Secure customer access through PGE.com

Energy use by hour or day

View by week, by month, or by billing cycle

Temperature overlay

Estimated electric bill-to-date

Estimated bill forecasts

Average daily electric charges

Year-over-year comparison

Neighborhood comparison

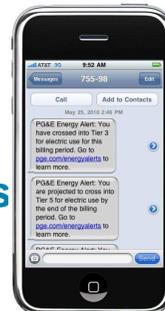
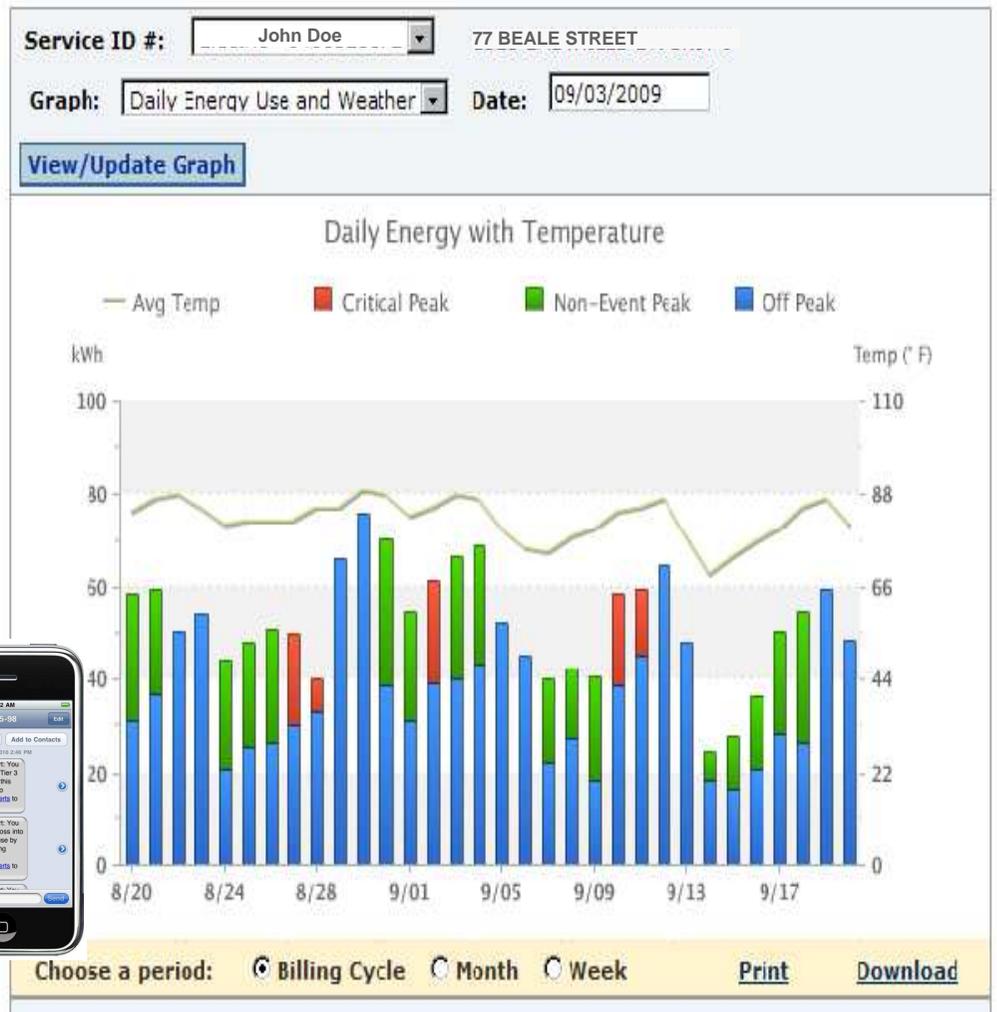
Customer service representatives can view same graphs

Receive energy alerts via smart phones

SmartMeter™ Usage

Please note that SmartMeter™ usage for today will be available tomorrow between 3–10 pm.

Please be aware that the energy usage data presented here may differ slightly from the energy usage data reflected on your monthly bill. Be assured that prior to your monthly bill date, your energy usage data is validated to ensure you receive an accurate bill.





More Products Under Development

Home Energy Reports

Web Tools

Your Home Energy Report
 Account number: 123456789
 Report period: 03/13/10 - 04/13/10

Be Informed: This personalized report is an educational tool to show your home's energy use.

Be a Program Ambassador: We'd like PG&E employees to have a firm understanding of the tools and resources we plan to offer our customers to help manage energy costs.

Talk to us: We want your feedback on this program and encourage you to call the help line with questions at 1-866-767-4467 or submit your feedback to homeenergyreports@pge.com.

BOB SMITH
 123 MAIN ST
 SAN FRANCISCO CA 94114

Last Month Household Comparison | You used 13% LESS energy than efficient similar homes.

YOUR HOME 702*

Efficient Similar Homes 810

Similar Homes 1,103

How you're doing:

GREAT 😊

Good 😊

More than average

*This energy index combines electricity (kWh) and natural gas (therms) into a single measurement.

What Homes Are Compared?

Similar Homes: Approximately 100 occupied, nearby homes that are similar in size to yours (avg 2,856 sq ft) and have both electricity and natural gas service.

Efficient Similar Homes: The most efficient 20 percent of similar homes.

SmartMeter™ Technology Gives You More Control Over Your Energy Use

See Your Power
With information made available by your SmartMeter™ device, you can now see how and when you are using energy so you can lower your overall energy bills. Visit www.pge.com/smartmeter to learn more about tools and services.

See When You Use Energy
Learn how much energy you use during the day and compare day-to-day energy use.

Sign Up for Energy Alerts
Receive a phone call, email or text message informing you when you're moving into a higher-priced tier.

Turn over for savings →

Personalized tips chosen for you based on your energy use and housing profile

Smart Purchases
Save a lot by spending a little

- Spotlight your work spaces**
Whether you're preparing dinner, writing at a desk, or reading a book, light is important. Instead of spreading it around the room, focus light where you need it most.
- Pay less to keep outdoor lights on**
Operating outdoor lights all night could cost you over \$40 per year on your electric bill. Luckily, you can reduce energy usage without sacrificing security or style.

Great Investments
Big ideas for big savings

- Pay less to keep outdoor lights on**
Operating outdoor lights all night could cost you over \$40 per year on your electric bill. Luckily, you can reduce energy usage without sacrificing security or style.
- Pay less to keep outdoor lights on**
Operating outdoor lights all night could cost you over \$40 per year on your electric bill. Luckily, you can reduce energy usage without sacrificing security or style.

SAVE UP TO **\$200** PER YEAR

SAVE **\$15** OR MORE PER YEAR

SAVE UP TO **\$35** OR MORE PER LIGHT ANNUALLY

runs on OPOWER

Usage Details

Pam's B&B Morro Bay - XXXX

Show my electricity by year

Apr 2009 - Apr 2010

Neighbor comparison

Find tips to reduce your use:

- Free steps to take
- Smart purchases
- Great investments

My Rates Pam's B&B Morro Bay - XXXX

We've estimated your costs for each rate option.

Rate Option	Your estimated cost (cents)	Lowest Cost
AG-1B Medium Time-of-Use	\$5600 _{yr}	
AG-4B Medium Time-of-Use	\$5000 _{yr}	Save \$600/yr
AG-4C Medium Time-of-Use	\$5230 _{yr}	Save \$370/yr
AG-4C Peak Day Pricing	\$5405 _{yr}	Save \$195/yr
AG-5B Large Time-of-Use	\$5770 _{yr}	

- Easy-to-understand designs
- Personalized information
- Tips and programs to encourage energy conservation and efficiency

- Usage and cost analysis
- Bill comparison
- Progressive energy audit
- Rate analysis tool
- Personalized tips and goal tracking



Customer Energy Management Home Area Networks

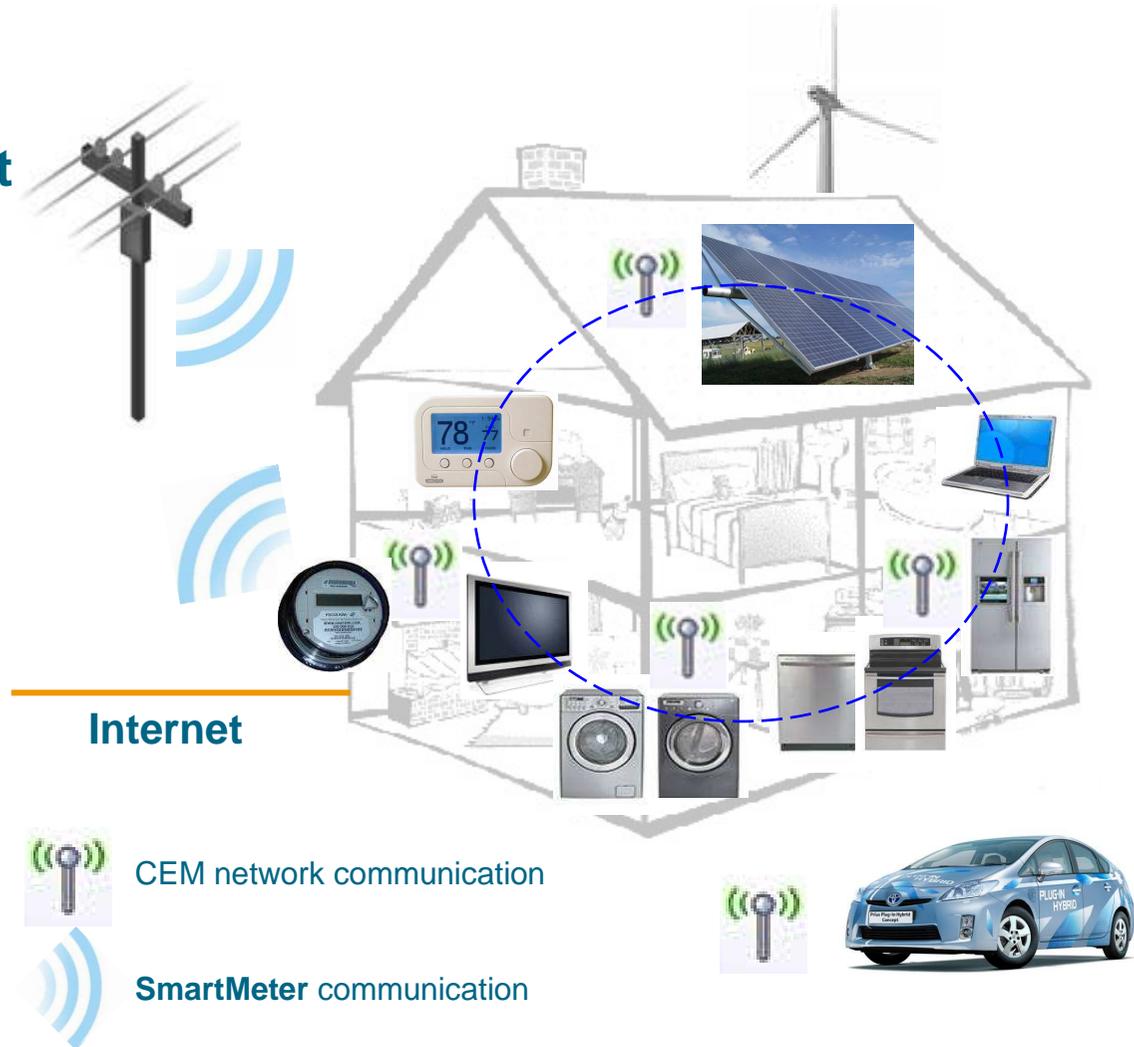
Communications & Demand-Side Management

From meter to the home:

- Timely price signals
- Appliance / energy management control signals

From meter to utility:

- Customer electric use
- Customer energy generation (e.g. solar)
- Appliance response to energy management control signals





Integrated Demand-Side Management & Renewable Resources



Automated management of energy use:

- Automated demand response
- Voluntary load control
- Dynamic pricing
- Energy Efficiency



On-site generation and storage



Smart charging for electric vehicles





Thank You

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Educational Background	Bachelor of Arts in Management Saint Mary's College, Moraga, California, USA	
Work Experience	Pacific Gas and Electric Company Information Systems and Technology Services Automation Engineering - Distribution Electric Meter Engineering Electric Meter Operations Electric Substation Operations Electric Transmission and Distribution - Underground	
Autobiography Belvin Louie is currently an Information Technology Solution Architect at Pacific Gas and Electric Company (PG&E). He has a broad base of experience with strategic technologies, business operations, and project management. In particular, he has direct hands on experience with electric transmission and distribution operations, automatic metering technologies, supervisory control and data acquisition (SCADA) systems, distribution automation and protection systems, and advanced communication technologies. As the designer and lead architect of PG&E's SmartMeter system, his recent efforts had been focused on leveraging the SmartMeter technology platform to improve operational efficiencies and customer services, and increasingly, on smart grid, demand-side management, home area networks, and plug-in hybrid electric vehicles.		